Polarized Gun R&D at Fermilab

American Linear Collider Workshop

2003

Cornell University, Ithaca NY

Objective

- RF Guns are proven to deliver high brightness beams
- At Fermilab we explore the possibility of flat beam production
- Wouldn't it be attractive to combine this with spin polarization?

Objective

- Polarized guns require GaAs cathodes
- GaAs cathodes require excellent vacuum (10^{-12} Torr)
- The vacuum in rf guns typically ranges around 10^{-9} Torr
- Need to improve the vacuum drastically

Idea

- Operate the gun at cryogenic temperatures to lower the equilibrium pressure
- Superconducting gun prevents the use of solenoids -> ruled out
- Operate copper gun at liquid nitrogen temperature

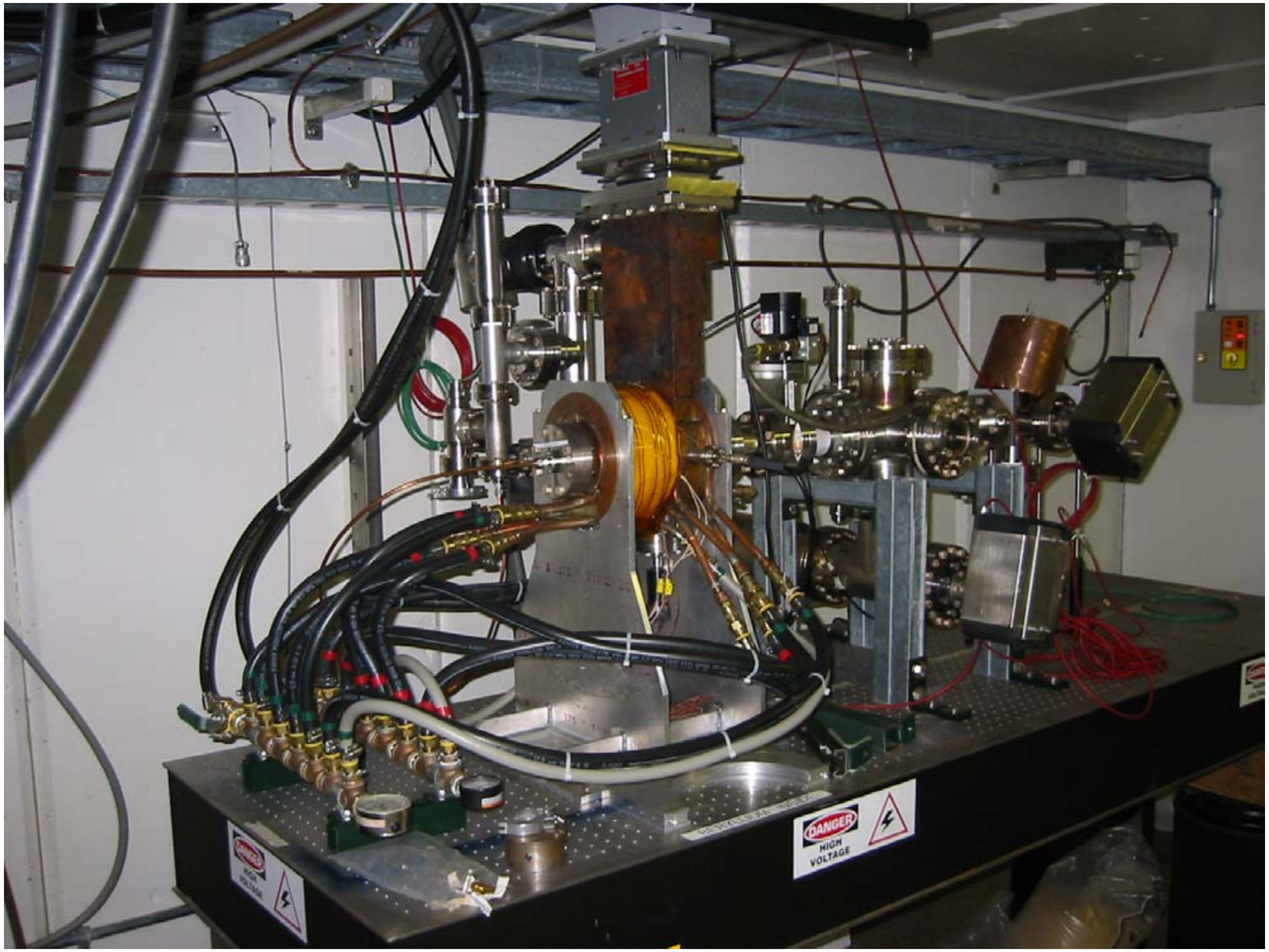
Idea

- Gas desorption strongly depends on temperature

$$\frac{dN}{dt} \propto N \exp\left(-\frac{E}{RT}\right)$$

for $E \approx 10$kJ/mol -> factor 10^5!

Prototype Gun



Prototype Gun

- **Prototype gun available at Fermilab:**
  ->1.6 cell L-band gun (1.3 GHz)
  -> at 35 MV/m dissipates 2.2 MW
  -> TESLA parameters: 900 μs, 5 Hz

Prototype Gun

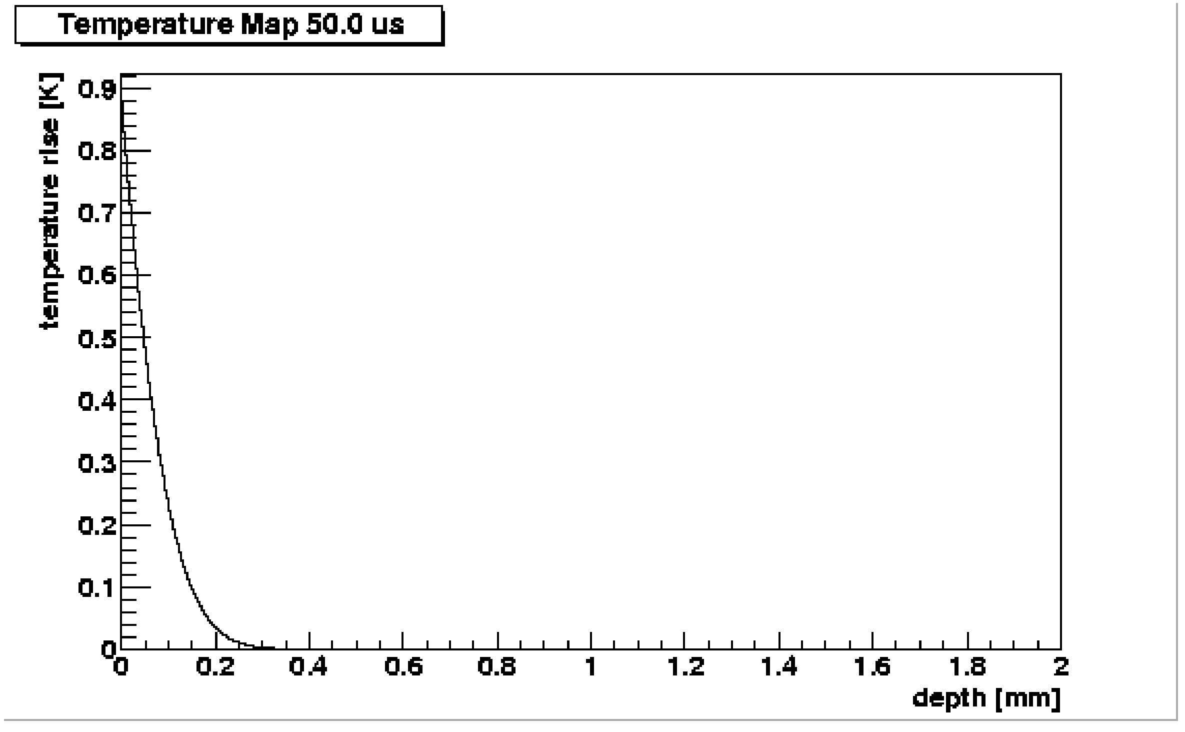
- At 80 K the dissipated power is reduced by a factor of 2.8
  -> 780 kW peak power
  -> 3.5 kW average power
  -> Heat flux at cooling pipes 2.5 W/cm^2 (nucleate boiling limit 15 W/cm^2) maximum in iris with 3.1 W/cm^2

Temperature Distribution

- **Temperature rises with**

$$T = I\sqrt{\frac{4t}{\pi\rho c\lambda}}$$

Temperature Distribution



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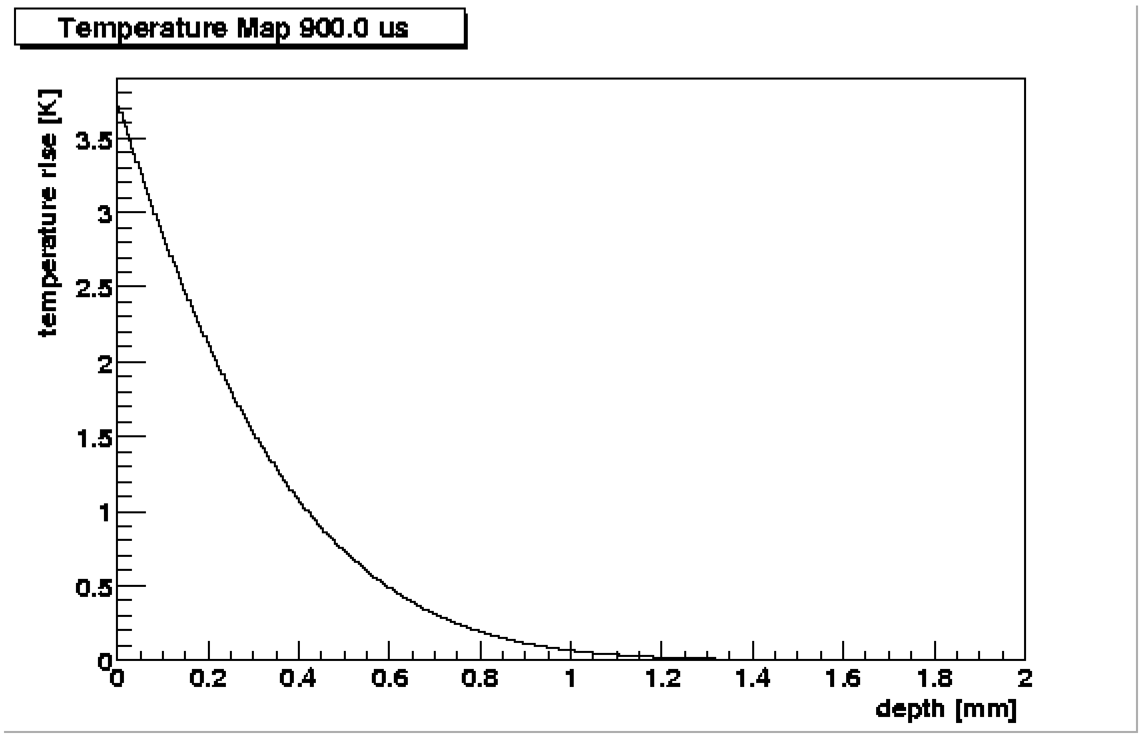
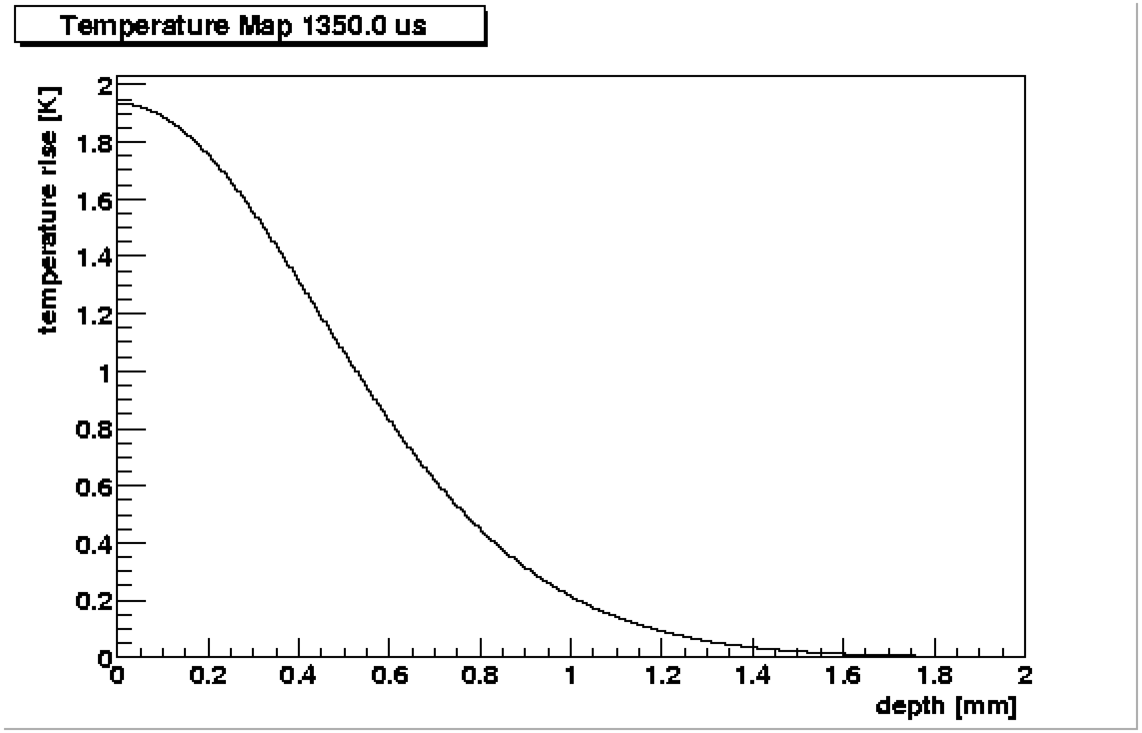


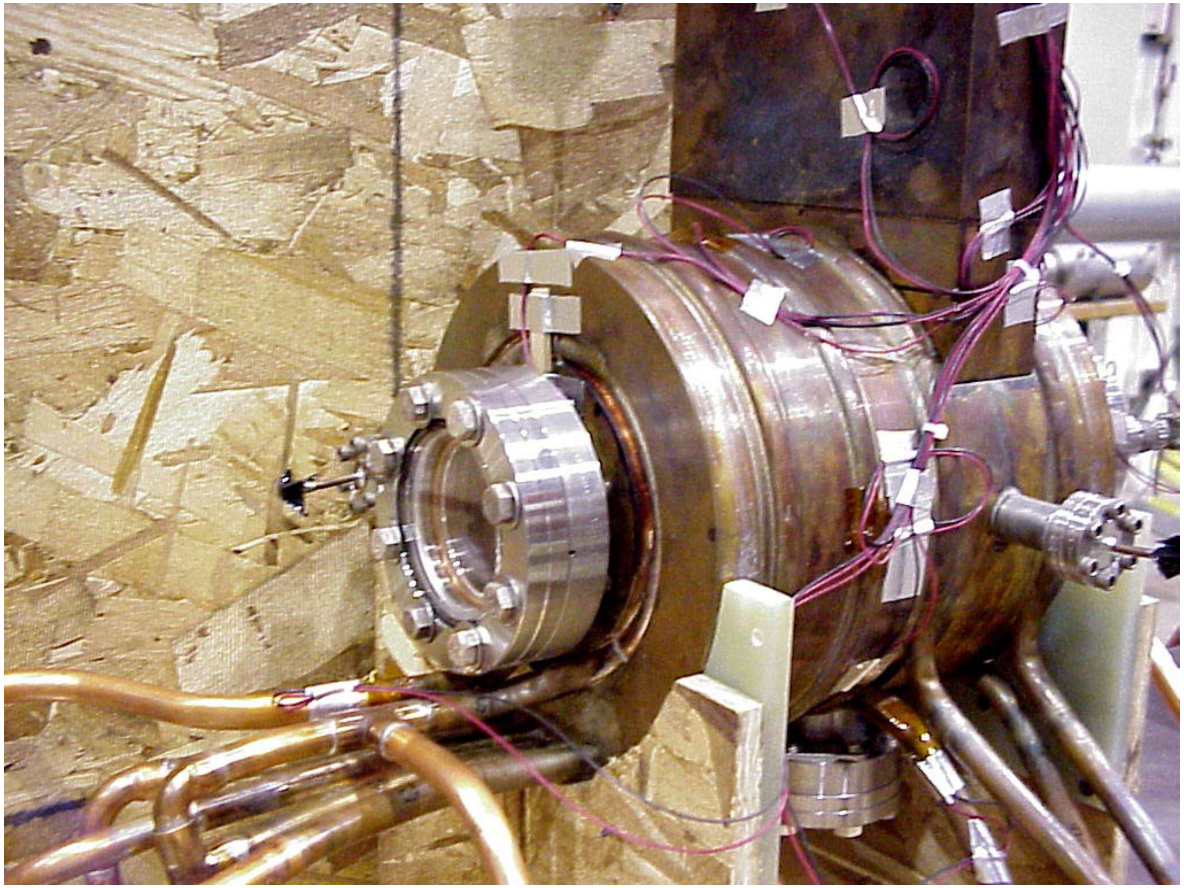
Temperature Distribution



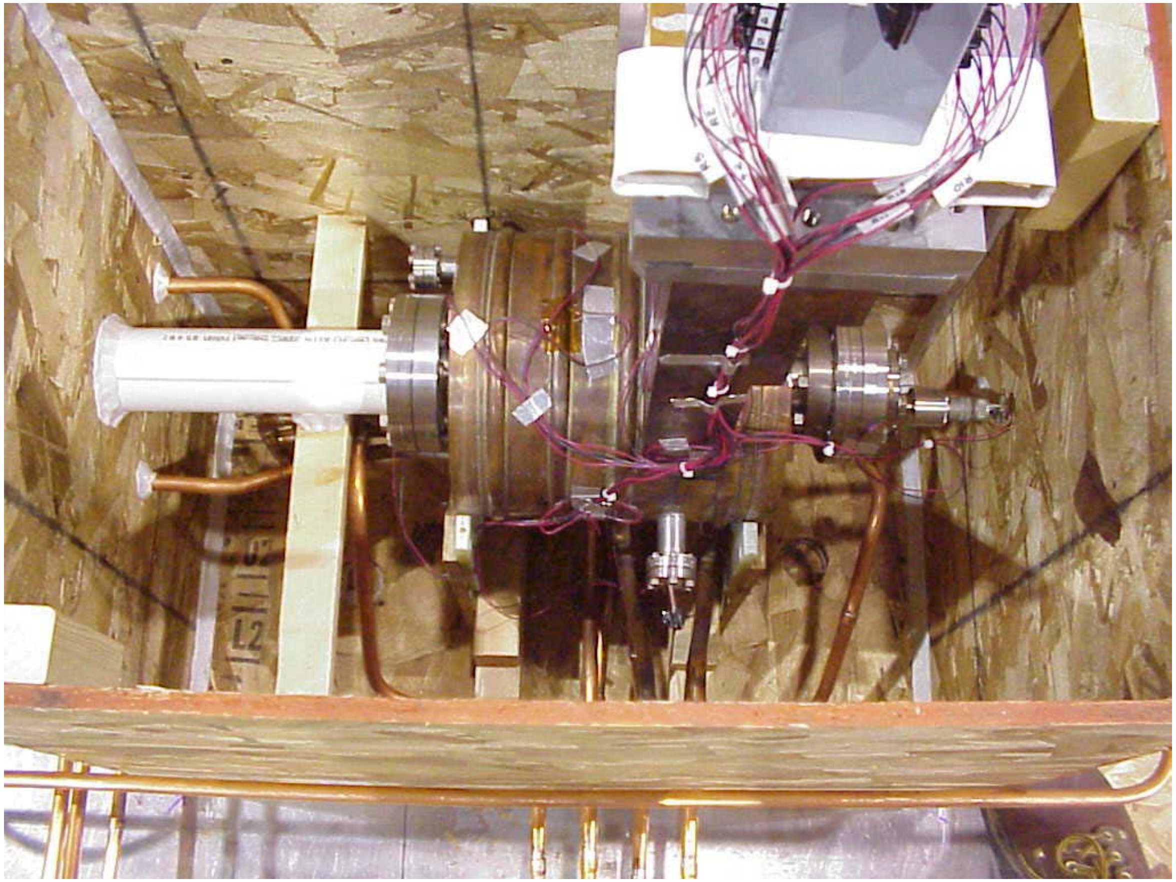
Phase I: Vacuum Tests

- Cool down to 80 K
  -> measure pressure, RGA
- Apply RF
  -> measure pressure, RGA
  -> measure dark current

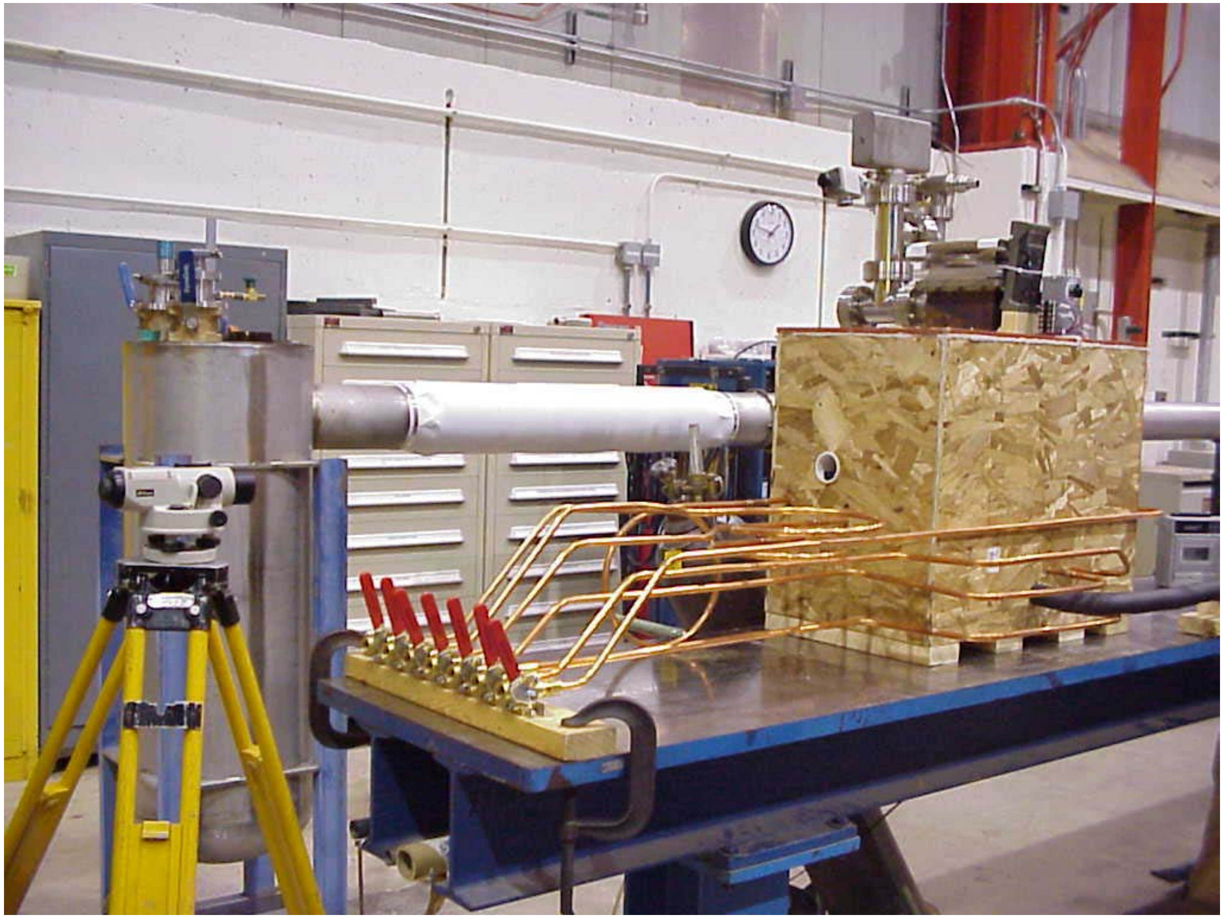
Phase I: Vacuum Tests



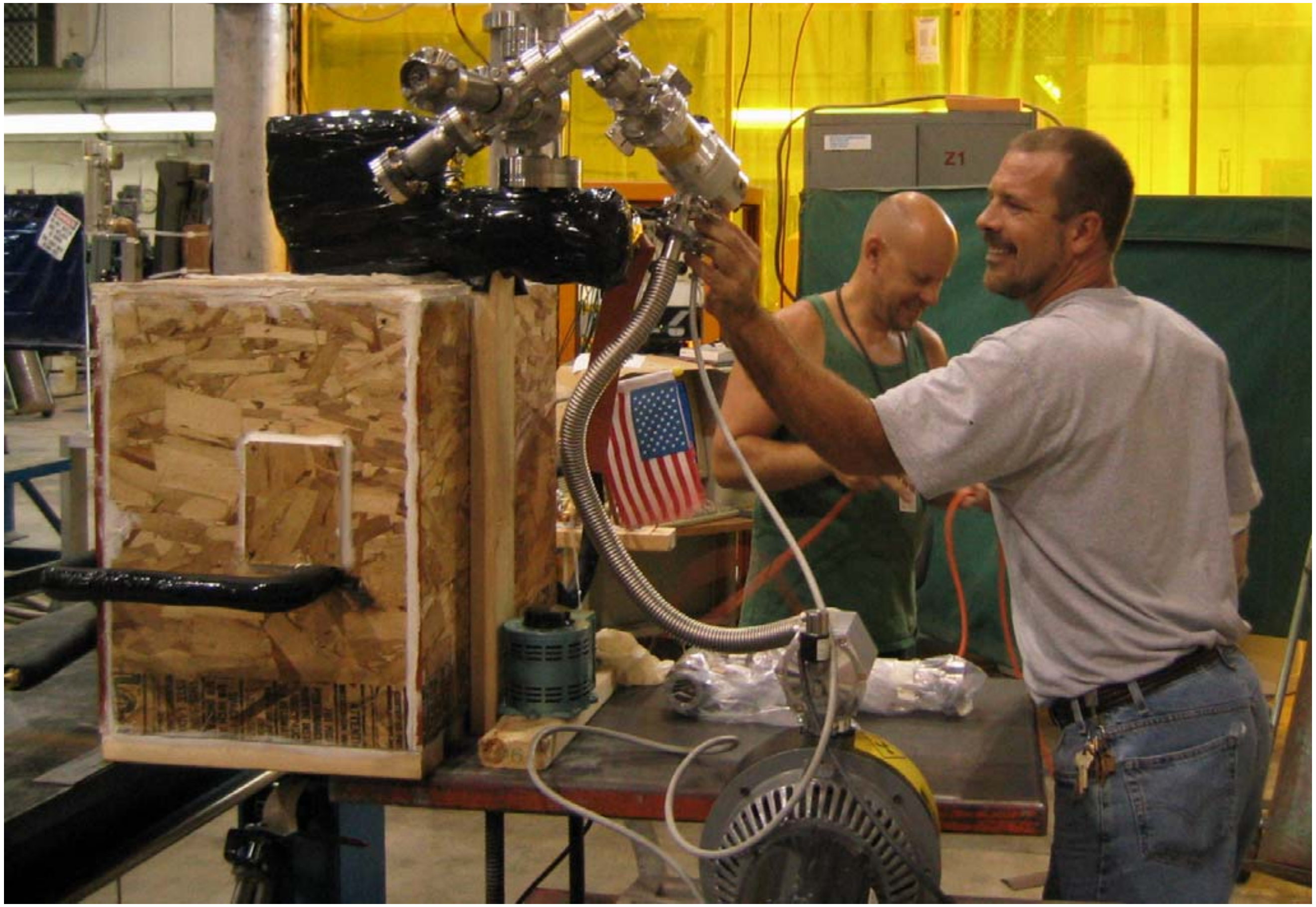
Phase I: Vacuum Tests



Phase I: Vacuum Tests



Phase I: Vacuum Tests



Phase I: Vacuum Tests

- Initial test: Thursday
- Cleaning: Soon afterwards
- Test with rf: This summer
- Decision to proceed: Thereafter

Phase II: Quantum Efficiency

- Built a cathode system
- Obtain a (set of) cathode(s)
- Laser diode for Q.E. measurements
- Cryostat
- Measure Q.E. lifetime, dark current

Phase III: Gun Design

- Design a “usable” gun
- Options for reduction of average rf power?
  -> reduce heat load
  -> reduce dark current

Phase III: Gun Design

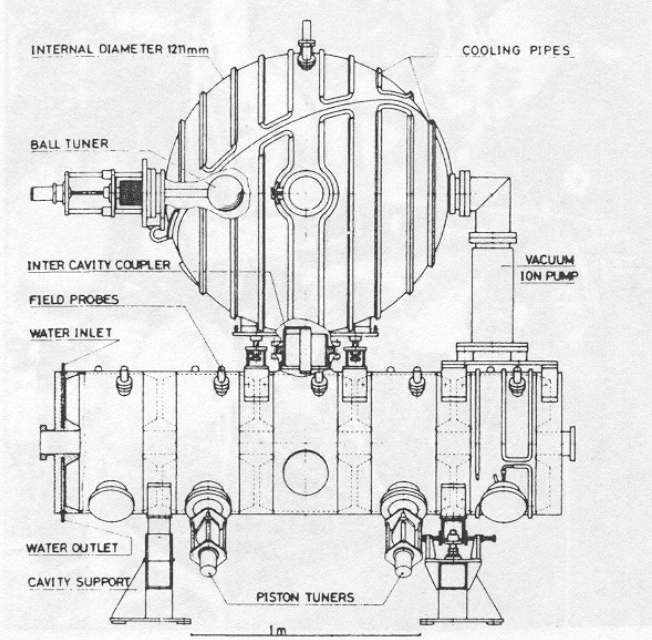


Fig. 5. Arrangement of coupled cavity system for LEP

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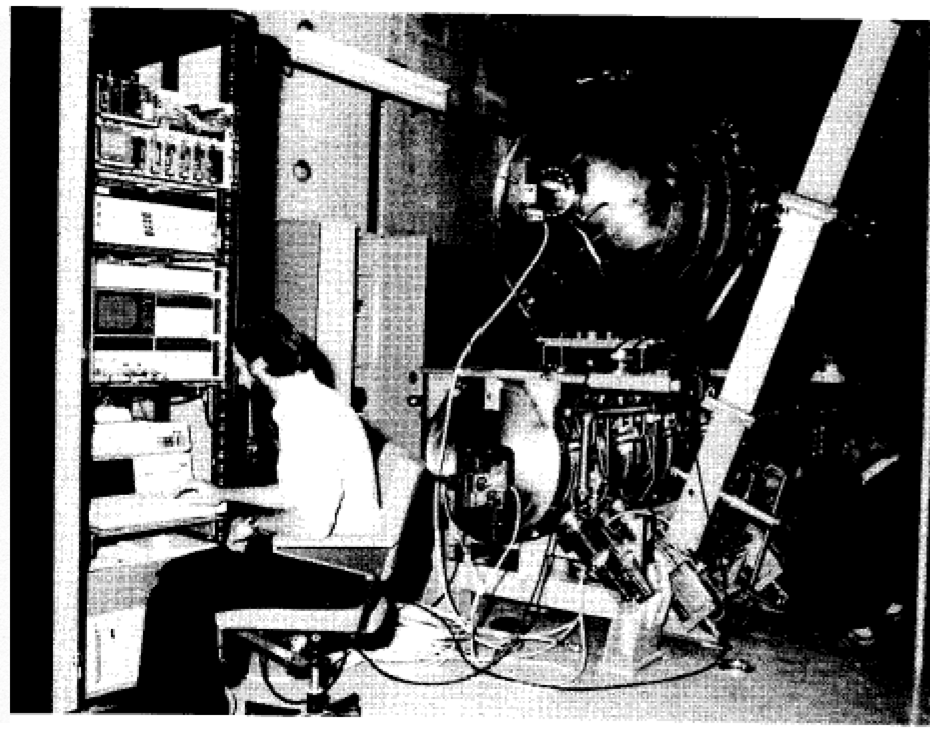

Fig. 7. Arrangement for coupler adjustments

LEP Note 570

Phase III: Gun Design

- Coupled acceleration and storage cavity
- Storage cavity superconducting
- Storage cavity on axis

Thank You